

2.4.4 Soil Saturation Limit. The soil saturation concentration (C_{sat}) corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil contaminant may be present in free phase, i.e., nonaqueous phase liquids (NAPLs) for contaminants that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures.

Derivation of the Soil Saturation Limit

$$C_{sat} = \frac{S}{\rho_b} (K_d \rho_b + \theta_w + H' \theta_a) \quad (9)$$

Parameter/Definition (units)	Default	Source
C_{sat} /soil saturation concentration (mg/kg)	–	
S/solubility in water (mg/L-water)	chemical-specific	see Part 5
ρ_b /dry soil bulk density (kg/L)	1.5	U.S. EPA, 1991b
K_d /soil-water partition coefficient (L/kg)	$K_{oc} \times f_{oc}$ (organics)	
K_{oc} /soil organic carbon/water partition coefficient (L/kg)	chemical-specific	see Part 5
f_{oc} /fraction organic carbon of soil (g/g)	0.006 (0.6%)	Carsel et al., 1988
θ_w /water-filled soil porosity (L_{water}/L_{soil})	0.15	EQ, 1994
H' /dimensionless Henry's law constant	$H \times 41$, where 41 is a conversion factor	U.S. EPA, 1991b
H /Henry's law constant (atm-m ³ /mol)	chemical-specific	see Part 5
θ_a /air-filled soil porosity (L_{air}/L_{soil})	0.28	$n - \theta_w$
n /total soil porosity (L_{pore}/L_{soil})	0.43	$1 - \rho_b/\rho_s$
ρ_s /soil particle density (kg/L)	2.65	U.S. EPA, 1991b

Equation 9 is used to calculate C_{sat} for each site contaminant. As an update to RAGS HHEM, Part B, this equation takes into account the amount of contaminant that is in the vapor phase in the pore spaces of the soil in addition to the amount dissolved in the soil's pore water and sorbed to soil particles.

Chemical-specific C_{sat} concentrations must be compared with each volatile inhalation SSL because a basic principle of the SSL volatilization model (Henry's law) is not applicable when free-phase contaminants are present (i.e., the model cannot predict an accurate VF or SSL above C_{sat}). Thus, the VF-based inhalation SSLs are applicable only if the soil concentration is at or below C_{sat} . When calculating volatile inhalation SSLs, C_{sat} values also should be calculated using the same site-specific soil characteristics used to calculate SSLs (i.e., bulk density, average water content, and organic carbon content).

At C_{sat} the emission flux from soil to air for a chemical reaches a plateau. Volatile emissions will not increase above this level no matter how much more chemical is added to the soil. Table 3-A shows that for compounds with generic volatile inhalation SSLs greater than C_{sat} , the risks at C_{sat} are significantly below the screening risk of 1×10^{-6} and an HQ of 1. Since C_{sat} corresponds to maximum

TOXICITY INFORMATION

OIL OR HAZARDOUS MATERIAL	SOLUBILITY µg/L	HENRY'S LAW CONSTANT conc/conc	Koc ml/g	Soil Saturation Level (Csat) mg/kg
ACENAPHTHENE	4.24E+03	6E-03	4.9E+03	
ACENAPHTHYLENE	3.93E+03	6E-02	2.5E+03	5.94E+01
ACETONE	1.00E+09	2E-03	5.8E-01	1.04E+05
ALDRIN	1.80E+02	7E+00	4.9E+04	
ANTHRACENE	4.34E+01	3E-03	2.4E+04	
ANTIMONY				
ARSENIC				
ASBESTOS				
BARIUM				
BENZENE	1.78E+06	2E-01	6.2E+01	9.12E+02
BENZO(a)ANTHRACENE	9.40E+00	1E-04	3.6E+05	
BENZO(a)PYRENE	1.62E+00	5E-05	9.7E+05	
BENZO(b)FLUORANTHENE	1.40E+01	5E-04	1.2E+06	
BENZO(g,h,i)PERYLENE	2.60E-01	6E-06	1.6E+06	2.50E+00
BENZO(k)FLUORANTHENE	8.00E-01	2E-03	1.2E+06	
BERYLLIUM				
BIPHENYL, 1,1-	7.50E+03	2E-02		7.73E-01
BIS(2-CHLOROETHYL)ETHER	1.72E+07	7E-04	7.6E+01	9.56E+03
BIS(2-CHLOROISOPROPYL)ETHER	1.70E+06	5E-03	6.1E+01	7.94E+02
BIS(2-ETHYLHEXYL)PHTHALATE	3.40E+02	4E-06	1.1E+05	2.26E+02
BROMODICHLOROMETHANE	6.74E+06	7E-02	5.5E+01	2.98E+03
BROMOFORM	3.10E+06	2E-02	1.3E+02	2.67E+03
BROMOMETHANE	1.75E+07	8E+00	5.9E+00	2.87E+04
CADMIUM				
CARBON TETRACHLORIDE	7.93E+05	1E+00	1.5E+02	9.87E+02
CHLORDANE	5.60E+01	2E-03	5.1E+04	
CHLOROANILINE, p-	5.30E+06	1E-05	6.6E+01	
CHLOROBENZENE	4.72E+05	2E-01	2.2E+02	6.95E+02
CHLOROFORM	7.92E+06	2E-01	5.3E+01	3.51E+03
CHLOROPHENOL, 2-	2.20E+07	2E-02	2.9E+02	4.00E+04
CHROMIUM (TOTAL)				
CHROMIUM(III)				
CHROMIUM(VI)				
CHRYSENE	1.60E+00	4E-03	4.0E+05	
CYANIDE	1.00E+09	8E+04		1.45E+10
DIBENZO(a,h)ANTHRACENE	2.49E+00	6E-07	1.8E+06	
DIBROMOCHLOROMETHANE	2.60E+06	3E-02	6.3E+01	1.26E+03
DICHLOROBENZENE, 1,2- (o-DCB)	1.56E+05	8E-02	3.8E+02	3.73E+02
DICHLOROBENZENE, 1,3- (m-DCB)	1.23E+05	1E-01	1.7E+03	1.27E+03
DICHLOROBENZENE, 1,4- (p-DCB)	7.38E+04	1E-01	6.2E+02	
DICHLOROBENZIDINE, 3,3'-	3.11E+03	2E-07	7.2E+02	
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	9.00E+01	2E-04	4.6E+04	
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	1.20E+02	9E-04	8.6E+04	
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	2.50E+01	3E-04	6.2E+05	
DICHLOROETHANE, 1,1-	5.06E+06	2E-01	5.3E+01	2.34E+03

TOXICITY INFORMATION

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DICHLOROETHANE, 1,2-	8.52E+06	2E+02	3.8E+01	3.93E+05
DICHLOROETHYLENE, 1,1-	2.25E+06	1E+00	6.5E+01	1.55E+03
DICHLOROETHYLENE, CIS-1,2-	3.50E+06	2E-01	3.6E+01	1.20E+03
DICHLOROETHYLENE, TRANS-1,2-	6.30E+06	4E-01	3.8E+01	2.52E+03
DICHLOROMETHANE	1.30E+07	9E-02	1.0E+01	2.30E+03
DICHLOROPHENOL, 2,4-	4.50E+06	1E-04	7.2E+01	
DICHLOROPROPANE, 1,2-	2.80E+06	1E-01	4.7E+01	1.13E+03
DICHLOROPROPENE, 1,3-	2.80E+06	7E-01	2.7E+01	1.11E+03
DIELDRIN	1.95E+02	6E-04	2.6E+04	
DIETHYL PHTHALATE	1.08E+06	2E-05	8.2E+01	6.41E+02
DIMETHYL PHTHALATE	5.00E+06	4E-06	3.1E+00	5.93E+02
DIMETHYLPHENOL, 2,4-	7.87E+06	8E-05	2.1E+02	1.07E+04
DINITROPHENOL, 2,4-	2.79E+06	2E-05	1.0E-02	
DINITROTOLUENE, 2,4-	2.70E+05	4E-06	9.6E+01	
DIOXANE, 1,4-	9.00E+08	2E-04	-0.27	8.86E+04
ENDOSULFAN	5.10E+02	5E-04	2.0E+03	
ENDRIN	2.50E+02	3E-04	1.1E+04	
ETHYLBENZENE	1.69E+05	3E-01	2.0E+02	2.34E+02
ETHYLENE DIBROMIDE	4.30E+06	3E-02	4.4E+01	1.59E+03
FLUORANTHENE	2.06E+02	7E-04	4.9E+04	
FLUORENE	1.98E+03	3E-03	7.7E+03	
HEPTACHLOR	1.80E+02	4E-02	9.5E+03	
HEPTACHLOR EPOXIDE	2.00E+02	4E-04	8.3E+04	
HEXACHLOROBENZENE	6.20E+03	5E-02	8.0E+04	
HEXACHLOROBUTADIENE	3.23E+03	3E-01	5.4E+04	1.04E+03
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	6.80E+03	6E-04	1.4E+03	
HEXACHLOROETHANE	5.00E+04	2E-01	1.8E+03	
HMX	6.63E+03	1E-13	5.4E-01	
INDENO(1,2,3-cd)PYRENE	2.20E-02	7E-05	3.5E+06	
LEAD				
MERCURY	5.60E+01	5E-01		1.05E-02
METHOXYCHLOR	4.50E+01	6E-04	8.0E+04	
METHYL ETHYL KETONE	2.75E+08	1E-03	3.5E+00	3.34E+04
METHYL ISOBUTYL KETONE	1.91E+07	6E-03	3.1E+00	2.28E+03
METHYL MERCURY		5E-01		
METHYL TERT BUTYL ETHER	4.80E+07	2E-02	3.1E+00	5.91E+03
METHYLNAPHTHALENE, 2-	2.46E+04	2.04E-02	2.5E+03	3.72E+02
NAPHTHALENE	3.10E+04	2E-02	1.2E+03	
NICKEL				
PENTACHLOROPHENOL	1.95E+06	1E-06	4.1E+02	

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PETROLEUM HYDROCARBONS				
Aliphatics				
C5 to C8		5.4E+01	2265	
C9 to C12		6.5E+01	150000	
C9 to C18		6.9E+01	680000	
C19 to C35				
Aromatics				
C9 to C10		3.3E-01	1778	
C11 to C22		3.0E-02	5012	
PHENANTHRENE	8.16E+02	2E-03	1.4E+04	6.86E+01
PHENOL	8.28E+07	2E-05	2.9E+01	
POLYCHLORINATED BIPHENYLS (PCBs)	5.70E+01	8E-02	3.1E+05	1.06E+02
PYRENE	1.35E+02	5E-04	6.8E+04	
RDX	6.00E+04	5E-04	6.3E+01	
SELENIUM				
SILVER				
STYRENE	3.10E+05	1E-01	9.1E+02	1.73E+03
TCDD, 2,3,7,8- (equivalents)	1.93E-02	9E-02	3.3E+06	3.82E-01
TETRACHLOROETHANE, 1,1,1,2-	2.90E+06	5E-01	5.4E+01	1.47E+03
TETRACHLOROETHANE, 1,1,2,2-	2.97E+06	1E-02	7.9E+01	1.71E+03
TETRACHLOROETHYLENE	2.00E+05	8E-01	2.7E+02	3.66E+02
THALLIUM				
TOLUENE	5.26E+05	3E-01	1.4E+02	5.21E+02
TRICHLOROBENZENE, 1,2,4-	3.00E+05	6E-02	1.7E+03	3.02E+03
TRICHLOROETHANE, 1,1,1-	1.33E+06	7E-01	1.4E+02	1.39E+03
TRICHLOROETHANE, 1,1,2-	4.42E+06	4E-02	7.5E+01	2.46E+03
TRICHLOROETHYLENE	1.10E+06	4E-01	9.4E+01	8.19E+02
TRICHLOROPHENOL, 2,4,5-	1.20E+06	2E-04	3.0E+02	
TRICHLOROPHENOL 2,4,6-	8.00E+05	3E-04	1.3E+02	
VANADIUM				
VINYL CHLORIDE	2.76E+06	1E+00	1.9E+01	1.15E+03
XYLENES (Mixed Isomers)	1.75E+05	3E-01	2.5E+02	2.88E+02
ZINC				